REMARKS

A. Amendments to the Claims

Claim 10 is amended to indicate that the structural component is "adapted" to reach a temperature of at least about 950 °C for a duration of at least about 80 hours and to be within about 3 cm to about 5 cm of the silicon single crystal or a silicon melt. Claim 14 is amended to independent form and is directed to an apparatus comprising a plurality of structural components adapted as set forth above wherein each structural component corresponds to the structural component set forth in claim 1 from which claim 14 previously depended. No new matter is added by the foregoing amendments.

B. Definiteness and Utility

Reconsideration is respectfully requested of the rejections of claims 10 and 14 pursuant § 112-2nd Paragraph and § 101 for being indefinite and unclear.

Rather than including process parameters in the claims, claims 10 and 14, as amended, contain a structural description that indicates the type and/or location of the components within the crystal growing apparatus. In view of the foregoing, the Applicants submit that the requirements of § 112-Second Paragraph and § 101 are satisfied and request withdrawal of the rejections.

C. Nonobviousness of the Claims 1-14

Reconsideration is respectfully requested of the rejection of claims 1-14 as being unpatentable, at least in part, over Holder et al.

Claim 1 is directed to a crystal pulling apparatus for producing a silicon single crystal grown by the Czochralski process. The structural component comprises a substrate and a protective layer covering the surface of the substrate inside the growth chamber. The substrate comprises graphite and has a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3. The protective layer comprises silicon carbide and has a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3.

Likewise, Holder et al. disclose a crystal pulling apparatus comprising a growth chamber and a structural component disposed within the growth chamber. The

structural component comprises graphite and has a protective layer covering the graphite. Holder et al. disclose that the graphite has less than about 20 ppm total metals such as iron, molybdenum, copper, and nickel, and preferably has less than about 5 ppm total metals.[1] Holder et al. also disclose that as the purity of the graphite increases, the amount of particle generation during high temperature heating decreases.[2] Additionally, Holder et al. disclose that the protective layer may comprise between about 99.9% to about 99.99% silicon carbide and between about 0.01% to about 0.1% silicon, preferably about 99.9% silicon carbide and about 0.1% silicon.[3]

To render a claim obvious, the prior art reference (or references when combined) must teach or suggest all of the claim limitations.[4] Holder et al. fail to disclose, teach or suggest coating a graphite substrate with a silicon carbide protective layer having a concentration of iron no greater than about $1.0*10^{12}$ atoms/cm^3 as required by claim 1. Despite the fact that Holder et al. do not specify an iron content in the protective layer, the Office asserts that the disclosed protective layer must have an iron concentration of zero because the disclosed relative amounts of silicon carbide and silicon in the protective layer equals 100%. However, Holder et al.'s description of 99.9-99.99% SiC and 0.01-0.1% Si with no specification of impurities is merely a nominal or theoretical composition. Specifically, one of skill in the art would not interpret the description that the coating is "preferably about 99.9% silicon carbide and about 0.1% silicon" to indicate the coating is **completely free** of impurities. In fact, at page 3, lines 17-20 Holder et al. disclose that the "the typical silicon carbide coating provided by industry is itself contaminated with about 1 ppma iron." This express disclosure must be considered when determining what Holder et al. taught to one of ordinary skill in the art. As stated in *In re Mercier*, 185 USPQ 774, 778 (CCPA 1975):

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[1] Holder et al. (WO 99/66108) at page 7, lines 10-16.

[2] Holder et al. at page 7, lines 16-18.

[3] Holder et al. at page 10, lines 25-33.

[4] MPEP 2143.

> ... all the relevant teachings of the cited references must be considered in determining what they fairly teach to one having ordinary skill in the art. . . . The relevant portions of a reference include not only those teachings which would suggest particular aspects of an invention . . . but also those teachings which would lead such a person away from the claimed invention. . . . The board's approach amounts, in substance, to nothing more than a hindsight 'reconstruction' of the claimed invention by relying on isolated teachings of the prior art without considering the overall context within which those teachings are presented.

Additionally, The fact that the coating had impurities is further evident from the fact that Holder et al. disclosed that contaminants are released from the graphite components **or the silicon carbide**.[5] In view of the foregoing, one of skill in the art would conclude that the coating disclosed by Holder et al. contained impurities. Thus, it cannot be fairly said that Holder et al. disclose, teach or suggest including structural components that have a zero concentration of iron impurity in the silicon carbide protective coating.

Similarly, the Office's assertion that the disclosure by Holder et al. that the total concentration of metals in the graphite is less than about 20 ppm and preferably less than 5 ppm "overlaps" the range of iron concentration set forth in claim 1 is improper. Applicants submit that the total metal concentration levels disclosed by Holder et al. were merely that of commercially available graphite substrates and would not be interpreted by one of skill in the art to disclose, suggest, encompass, or overlap the extremely low iron concentration range of claim 1. Specifically, the requirement of claim 1 that the substrate have a concentration of iron no greater than about $1.5*10^{12}$ atoms/cm^3 is over 10,000 times lower than a 5 ppm concentration.[6] A decrease in iron of that magnitude was clearly not envisioned by Holder et al.

Furthermore, to establish a *prima facie* case of obviousness there must be some suggestion or motivation, either in the references themselves or in the knowledge

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[5] Holder et al. at page 10, lines 22-24.

[6] For example, the concentration of iron in a graphite substrate of 1 ppmw corresponds to $2.8 *10^{16}$ atoms/cm^3 and a concentration of 0.05 ppmw corresponds to $1.4*10^{15}$ atoms/cm^3. See, the Application at page 11, lines 12-14.

generally available to one of ordinary skill in the art, to modify the reference.[7] In the present case, there is no suggestion to modify the disclosure of Holder et al. to require that the graphite substrate and the silicon carbide layer have concentrations of iron no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. One possible source of such a suggestion to modify is the teachings of the prior art.[8] Although Holder et al. are concerned with controlling iron contamination of silicon by iron evolved from structural components, they do not teach or suggest reducing the concentration of iron in structural components. Rather, Holder et al. teach controlling iron contamination of the silicon ingot by gettering or capturing evolved metal impurities.[9] Specifically, Holder et al. disclose two methods of gettering metal impurities such as iron by utilizing the high affinity of silicon for such contaminants. The first embodiment comprises overlaying a silicon carbide or glassy carbon protective layer with a silicon layer.[10] The second embodiment comprises incorporating silicon with silicon carbide in a single protective coating.[11] As described above, the treatment of iron concentrations in the graphite and silicon carbide disclosed by Holder et al. is largely superficial and is consistent with their solution of controlling iron contamination of the ingot by gettering. Thus, Holder et al. do not teach or suggest decreasing the concentration of iron in the graphite and silicon carbide protective layer below conventional levels. Furthermore, the other cited references (i.e., Falster et al., Kim et al., and Luter et al.) fail to mention the possibility of iron in a silicon ingot or the structural components of a crystal growth apparatus. Thus, these references cannot be said to teach or suggest reducing the concentration of iron in the substrate and protective layer below the conventional levels disclosed by Holder et al.

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[7] MPEP 2142, Third Paragraph.

[8] MPEP 2143.01 (*quoting In re Rouffet*, 149 F.3d 1350, 1357, 47 USPQ2d 1453, 1457-58 (Fed. Cir. 1998)).

[9] Holder et al. at page 4, lines 1-5; page 6, lines 15-22.

[10] Holder et al. at page 6, lines 8-15; and page 7, line 19 to page 8, line 6.

[11] Holder et al. at page 6, lines 8-15; and page 10, lines 15-24.

Still further, there is a lack of motivation to modify Holder et al.'s support coating to have as low an iron concentration as required by claim 1 because of the iron contamination problem addressed by Holder et al. is significantly different from the problem faced by the Applicants. The present invention is directed toward an apparatus used to produce silicon that is substantially free of agglomerated defects. Such silicon is produced, in part, by decreasing the cooling rate of the growing ingot and maintaining the ingot at temperatures that keep intrinsic point defects mobile for longer periods of time. This is accomplished, in part, by designing the apparatus to have a closed hot zone which contains more structural components than an open hot zone. The additional structural components insulate the ingot thereby decreasing heat loss from the ingot. Said structural components, when growing silicon substantially free of agglomerated defects, are maintained at high temperatures for relatively long periods of time and this increases the propensity for iron to contaminate the ingot. The Applicants discovered that acceptable iron levels in the ingot could not be achieved using structural components with conventional iron concentrations in the substrate and coating. The Applicants discovered that to decrease the amount of iron in such an ingot the concentration of iron in both the substrate and protective layer had to be dramatically reduced. To that end, the Applicants determined that iron concentrations within the substrate and protective layer had to be no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively. Holder et al. were not faced with reducing iron contamination under such demanding process conditions nor with the increased number of structural components of a closed hot zone. Thus, they were not faced with the same problems as the Applicants. As a result, Holder et al. were not motivated to decrease the iron concentrations in conventional structural components let alone require the extremely low iron concentrations set forth in claim 1.

In view of the foregoing, the Office has failed to present a *prima facie* case of obviousness because the cited art fails to disclose, teach or suggest all the elements of claim 1. Specifically, the requirements of claim 1 that the concentrations of iron in the substrate and the protective layer be no greater than about $1.5*10^{12}$ atoms/cm^3 and $1.0*10^{12}$ atoms/cm^3, respectively, are nonobvious. As such, claim 1 is submitted as

patentable over Holder et al, Falster et al., Kim et al., Luter et al., or a combination thereof.

Further, claims 2-14 which depend directly or indirectly from claim 1, are also submitted as patentable for the same reasons as set forth above and in view of the additional requirements which they specify. For example, claims 2-6 which require still lower concentrations of iron in the substrate or the protective layer are patentable for the same reasons set forth for claim 1. Claims 7 and 8 which specify the thickness of the protective layer are patentable for the same reasons set forth for claim 1. Claim 9 which specifies that the protective layer covers the entire surface of the substrate is patentable for the same reasons as set forth for claim 1. In addition to reasons set forth for claim 1, claims 10-14 are patentable because they specify which particular structural components within the crystal pulling apparatus are to have the characteristics of the structural component set forth in claim 1. A crystal growing apparatus as set forth in claims 10-14 produces ingots with lower iron levels than ingots produced in an apparatus containing only conventional structural components. For example, a ingot grown in a conventional closed hot zone apparatus has an average iron concentration of 5-10 ppta and an edge iron concentration as high as 100 ppta,[12] whereas an ingot grown in an apparatus comprising six low-iron structural components selected from the list set forth in claim 11 has an average iron concentration below about 3 ppta and an edge iron concentration below about 5 ppta.[13]

[12] Application at page 6, lines 23-26.

[13] Application at page 13, lines 5-13.

Favorable consideration and allowance of claims 1-14 is respectfully requested.

A check for $110.00 is enclosed for the one-month extension fee. The Commissioner is hereby authorized to charge any additional fees which may be required to Deposit Account No. 19-1345.

Respectfully submitted,

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